TITLE OF THE INVENTION
Single Wheel Steering and Suspension System

CROSS-REFERENCE TO RELATED APPLICATIONS
Inventor claims benefit of filing date of application number 60/421,002 dated 10/25/2002

BACKGROUND OF THE INVENTION

The most common steering and suspension system used on bicycles and motorcycles is the telescopic fork. That design places high loads on the frame resulting in a heavy frame with a high center of gravity. Other disadvantages of that design include high manufacturing cost, high maintenance, high unsprung weight, and excessive road vibrations transferred to the rider's arms. Additionally, complex anti-dive systems are required to eliminate suspension compression during braking.

Many designs have been proposed in an attempt to alleviate or mitigate these shortcomings. . The referenced patents disclose designs that are the most applicable to this invention. Some of these designs have been used successfully on racing motorcycles in the past and have demonstrated superior handling characteristics compared to the telescopic fork. They have not made it to the mass production market for one or more of the following reasons; high manufacturing cost, high steering inertia, high unsprung weight, poor later stiffness, poor torsional stiffness, and limited wheel turning angle. The invention disclosed herein does not possess these disadvantages.

SUMMARY OF THE INVENTION
The steering and suspension system disclosed herein consists of four major components; a wheel axle, two side rails, and a rear rail. The side rails are equal in length and positioned along each side of the wheel of the vehicle which is rotatably mounted on the axle. The rear rail is significantly longer than the axle and is positioned so that its centerline is perpendicular to the longitudinal axis of the vehicle and therefore parallel to the axle when the vehicle wheel is in the straight position. The rear rail is spaced rearward from the axle a distance equal to the radius of the vehicle wheel plus a small amount for clearance. The forward end of each side rail is

pivotally attached to each end of the axle. The rear end of each side rail is pivotally attached to each end of the rear rail. Thus in the top view with the axle in the straight position, the system forms an isosceles trapezoid, with the axle representing the top, the side rails representing the sides, and the rear rail representing the base. At each of the four corners are the pivots whose axes are parallel to each other and perpendicular to the axle centerline. They only allow movement in a plane that is perpendicular to the plane of rotation of the wheel. Although a simple pivot design will be described herein, many other designs are possible. Therefore, it is not the intent of this application to limit the use of any one particular pivot design and the description of the pivots will not be extensive or detailed.

A turn is performed by applying a fore or aft force to a lever attached to one end of the axle. Conventional control rods with ball joints are used to apply the force. This will cause the wheel axle to rotate about the forward pivots of the side rails which in turn causes the side rails to pivot about their rear pivots. Note that the maximum turning angle of the wheel is limited by the clearance between the rear portion of the wheel and the side rails. A number of design parameters affect this clearance but the length of the rear rail has the strongest influence on this clearance. More specifically the ratio of the distance between the rear pivots and the distance between the forward pivots should be at least 2 or 3 to 1. For example, if the distance between the forward pivots (the axle bracket pivots) is 7 inches, then the distance between the rear pivots (essentially the rear rail) should be between 14 to 21 inches. The smaller value would allow an acceptable turning angle (10 to 15 degrees) for a racing applications due to the fact that turning a two wheeled vehicle at moderate to high speeds requires a turning angle of only a few degrees and low speed maneuvering is not an issue. The larger value would allow an acceptable turning angle (20 to 30 degrees) for street applications where low speed maneuvering is important such as in a parking lot. It would be possible to use a ratio larger than 3, but the overall width may become excessive and this would limit the amount of lean angle during a turn because the pivots or other parts may scrape the ground.

In order to give the vehicle wheel suspension movement, the rear rail is pivoted about a pivot pin

with an axis that is perpendicular to the vehicle longitudinal axis and perpendicular to the plane of rotation of the wheel. For simplicity, the pivot axis is chosen to be coaxial with the centerline of the rear rail although other arrangements are possible. This pivot pin is attached to brackets fixed to the vehicle frame. A standard suspension unit (a coil-over-shock unit for example) is connected to the rear rail through a rocker-type progressive rate linkage. This allows the forward ends of the side rails and the axle to move vertically in an arc in the same manner as a typical rear swing arm suspension.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a top view of the steering system with the common suspension parts omitted for clarity.

Figure 2 is a side view of the steering and suspension system.

Figure 3 is an end view of the axle and axle brackets.

Figure 4 is a top view of the steering system during a turn with a small value for the axle offset design parameter.

Figure 5 is a top view of the steering system during a turn with a large value for the axle offset design parameter.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 1, the axle 1 is rigidly connected to the axle brackets 5 and 6. The axle brackets 5 and 6 are pivotally connected to the forward ends of side rails 2 and 3 through the pivot pins A and C. The rearward ends of rails 2 and 3 are pivotally connected to the rear rail brackets 8 and 9 through the pivot pins B and D. The rear rail brackets 8 and 9 are rigidly attached to the rear rail 4. The rear rail 4 is pivotally connected to frame brackets 10 and 11 through pivot pin E. Frame brackets 10 and 11 are rigidly attached to vehicle frame 12.

Control of the wheel 7 is performed by applying a torque to the steering post 19 through any convenient method such as handlebars (not shown). The steering post is rotatably attached to the vehicle frame 12 through the steering post support 18. The torque of the steering post 19 is

converted to a fore/aft force by the steering arm 17. This force is transmitted to the axle bracket 5 through the ball joint 16, the control rod 15, the ball joint 14, and the steering lever 13. The force causes the axle 1 and axle brackets 5 and 6 to rotate about pivot pins A and C. This causes the side rails 2 and 3 to rotate about pivot pins B and D.

Figure 2 shows the details of the suspension system. Concentrating on the left side, the rear rail 4 rotates about the pivot pin E along its centerline. Since the rear rail bracket 9 is rigidly attached to the rear rail 4, the bracket also rotates about pin E in the same manner. The left side rail 3 also rotates about pin E through the rear rail bracket 9 because pivot pin B is perpendicular to pivot pin E. This allows the axle bracket 5 and axle 1 to rotate about pivot pin E since pivot pin A is also perpendicular to pin E. Therefore, wheel 7 will move in an arc about pivot pin E. The movement of the wheel 7 is controlled by the suspension unit 23 through the suspension rocker 22, the suspension link 21, and the suspension lever 20 which is rigidly attached to the rear rail 4.

Figure 3 shows a design that rigidly attaches the axle to the axle brackets. The axle clamps 24 are split into an upper and lower half along the centerline of the axle. The upper half is rigidly attached to the brackets and the lower half secures the axle to the upper half through the bolts 25. This clamping design was chosen because it is similar that used on existing front fork systems and therefore a standard axle and wheel can be used. Other designs are possible and the steering system disclosed herein is not restricted to any particular axle or bracket design.

There are a number of design parameters of this steering system that affect the handling characteristics and stability of a two wheeled vehicle. Fortunately, the vehicle stability is relatively insensitive to most of these parameters and a complete discussion of all of the parameters is not necessary. However, it has been discovered that one of the parameters has a very strong influence on stability and therefore a discussion of that parameter is warranted.

When the steering system disclosed in this application is in a turn, the center of the axle (and therefore the tire contact patch) shifts laterally away from the longitudinal centerline of the

vehicle. The magnitude and direction of this displacement is critical to the stability of the vehicle and is strongly influenced by the longitudinal placement of the axle relative to the axes of the pivots that are attached to its ends. This distance between the axle centerline and an imaginary parallel line passing through the axes of the pivots is termed the Axle Offset (positive is defined as forward of the imaginary line). Figures 4 and 5 show the axle offset design parameter (shown as AO) and its effect on the lateral displacement of the tire contact patch during a turn. For the two cases shown, all other design parameters are equal and both are in a 15-degree turn. From the two figures it is evident that the axle offset should be kept large to minimize the amount of tire contact patch displacement. However, an excessively large axle offset will result in a tire contact patch that moves in the same direction that the vehicle is turning. The vehicle would then be difficult if not impossible to balance. Alternatively, a small axle offset (or negative value) results in a large tire contact patch displacement during even a small turn. The vehicle would then have overly sensitive handling characteristics. Therefore, there is an acceptable range of values for the axle offset and the actual value used for any particular design must be determined by testing.